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APPLICATIONS OF RANDOM DIFFERENTIAL EQUATIONS TO ENGINEERING SC--ETC(U)
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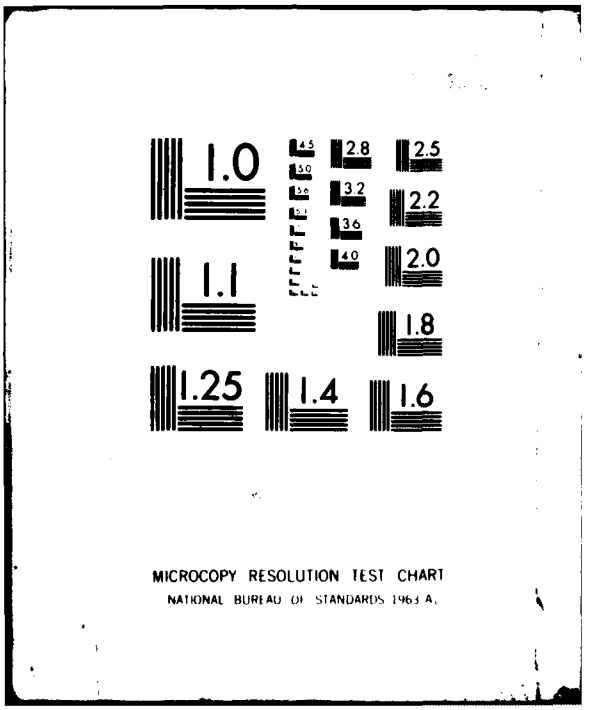
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FINAL REPORT

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TITLES OF PROPOSALS:

(1) Applications of Random Differential Equations to Engineering Science

(2) Wave Propagation in Turbulent Media and Random Linear Hyperbolic Systems

GRANT NUMBERS:

DAHC 04-75-G-0091
DAAG 29-76-G-0141
DAAG 29-78-G-0042

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I. Statements of Problems

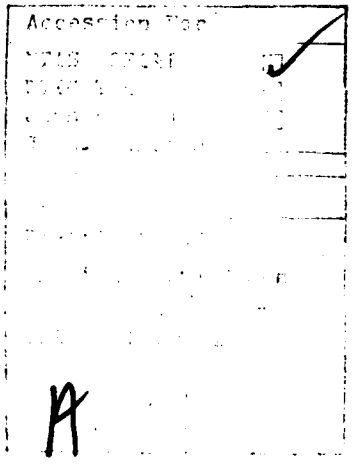
Research has been conducted in two major problem areas:

(1) Applications of Random Differential Equations to Engineering Science.

(2) Wave Propagation in Turbulent Media and Random Linear Hyperbolic Systems.

These two areas are not disjoint. In fact the second problem area is a follow-up study on problems in the first one with emphasis on wave propagation in turbulent media.

We have investigated several turbulence-related problems arising from engineering science. They include problems in wave propagation through turbulent media, turbulent transport theory, the surface roughness effect on hydrodynamic lubrication and wave scattering, and stability of elastic structures under random loading or with imperfections. In the theoretical aspect, the research is mainly concerned with the development of new methodology in solving differential equations with random coefficients, examination of the existing closure approximations with regards to their validity and possible improvements. Certain related mathematical questions are also studied.



II. Summary of Principal Results

A number of research findings has been reported in a series of semi-annual progress reports, which have been periodically submitted to ARO, during the course of the investigation. Instead of repeating the reported results, we shall only cite the major results and refer to the corresponding published papers, where the details can be found in the subsequent list of publications.

(1) Introduction of a powerful method - the functional phase-integral method, for treating high-frequency wave propagation in strong-turbulent media, with application to laser beam propagation [1,8,18].

(2) New approach to turbulence-related problems via stochastic partial differential equations and functional method [6,8,13].

(3) Analysis and solution of some random boundary problems in scattering of waves from a rough surface and surface roughness effect on the hydrodynamic lubrication [9,10,12,15].

(4) Development of stochastic stability theory for randomly perturbed periodic and continuous systems with applications [17,19,20].

(5) A general method for reconstructing the mutual coherent function of a static or moving source from the random radiation data [11,21].

III. List of papers published or submitted under ARO Sponsorship.

1. A functional phase-integral method and applications to the Laser beam propagation in random media. J. Stat. Phys. 12 (1975), 93-109.

2. Function-space differential equations associated with a stochastic partial differential equation. Indiana J. Math., 25 (1976), 609-627.

3. A perturbation problem in the scattering of waves. Rocky Mountain J. Math. 6 (1976), 745-754.

4. (with W. C. Tam) Periodic and traveling wave solutions to Volterra-Lotka equation with diffusion. Bull. Math. Biol. 38 (1976), 643-658.

5. (with C. H. Liu and L. Maestrello) Scattering of coherent sound waves by atmospheric turbulence. Progress in Astronautics and Aeronautics, 46 (1976), 51-66.

6. Notes on Stochastic Partial Differential Equations in Turbulence, in Statistical Mechanics Dynamical Systems and Turbulence (ed. by M. C. Reed), Duke Univ. Math. Series III (1977), VI-V25.

7. (with S. A. Williams) Nonlinear reaction-diffusion models for interacting populations. J. Math. Anal. & Appl, 1977, 157-169.

8. Stochastic Partial Differential Equations in Turbulence Related Problems, in Probabilistic Analy. and Related Topics, Vol.I (ed. by A.T. Bharucha-Reid), Academic Press, New York, 1978, 1-43.

9. Probabilistic model for the reflection of waves from a rough surface. SIAM J. Appl. Math., 35 (1978), 235-248.

10. (with E.A. Saibel) On the roughness effect on the hydrodynamic lubrication. J. Lubr. Tech., ASME Trans., 100 (1978), 176-180.

11. (with L. Maestrello) A stochastic inverse problem in the radiation of noise, SIAM J. Appl. Math., 35 (1978), 665-677.

12. (with E.A. Saibel) Analysis of stochastic Reynolds equation and related problem, Trans. 24th Conf. Army Wash., ARO Report 79-1 (1979), 413-420. Also in Constructive Approach to Math. Models (ed. by Coffman and Fix). Acad. Press, New York (1979), 321-326.

13. On linear stochastic PDE's and their applications, Analy. et Controle de Systems, INRIA Pub., Le Chesnay, France (1979), 43-50.

14. Approximate Solution of random evolution equations, in Approximate Solution of Random Eqs., (ed. A.T. Bharucha-Reid) North Holland, N.Y. (1979), 37-48.

15. Some random boundary problems in two dimensions, Applied Stochastic Processes (ed. by G. Adomain), Academic Press, New York, N.Y. (1980), 71-82.

16. (with A. Bensoussan and J.L. Lions), Filtering Theory for stochastic processes with two dimensional time parameter, Math. Computers in Simulation 22 (1980), 213-221.

17. (with K.L. Chiou) Asymptotic Stability of randomly perturbed linear periodic systems. SIAM J. Appl. Math., 40 (1981), 315-326.

18. Functional methods for waves in random media. Proc. Symp. Multiple Scattering and Waves in Random Media, North-Holland Pub. Co. (1981), 89-122.

19. Notes on the stability of randomly perturbed nonlinear reaction-diffusion systems. Trans. 26th Conf. Army Math., ARO Rep. 81-1, (1981), 67-74.

20. Stability of stochastic evolution equations. Math. Analy. & Appl. to appear in (1982).

21. Reconstruction of Mutual Coherence Function for a Moving Source, submitted to SIAM J. Appl. Math. (1981).

22. (with J.B. Keller) Propagation of mutual coherence in random media, (to be published).

23. Markov semigroup for the solution process of a stochastic evolution equation (in preparation).

24. (ed. with Kohler and Papanicolaou), Multiple Scattering and Waves in Random Media, Proc. of U.S. Army Workshop, North-Holland Publ. Co., Amsterdam, (1981).

(K. L. Chiou)

25. A note on the asymptotic behavior of nonlinear systems. Proc. Conf. Appl. Nonlinear Analy. (1979), 499-505.

26. Stability implications on the asymptotic behavior of nonlinear systems, Intern. J. Math. Appl. (1981), to appear.

27. On the asymptotic behavior of perturbed linear systems (submitted).

28. A note on self-contragradient operators and their applications is differential equations (submitted).

29. Nonoscillatory properties of second order delay-differential equations, (submitted).

IV. Scientific Personnel Supported by this Project and Degrees Awarded During the Reporting Period.

The following scientific personnel has been supported by the ARO in this project.

1. P. L. Chow (Principal Investigator)	2 summer months	x 5 (1975-1980)
	1 summer month	x 1 (1981)
	2½ acad. months	x 1 (sabbatical leave 1979)
2. K. L. Chiou (Co-investigator)	2 summer months	x 2 (1977-1978)
3. T. C. Sun (Co-investigator)	1 summer month	x 1 (1979)
4. S. L. Wang (student)	½ summer month	x 1 (1980)

There is no advanced degrees awarded under the ARO support.

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18. SUPPLEMENTARY NOTES

The view, opinions, and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other documentation.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Wave propagation, turbulence, random media, turbulent transport, rough surface, hydrodynamic lubrication, structure stability, random loading, random boundary, stochastic stability, random differential equations, stochastic partial differential equations, stochastic inverse problem, functional integrals.

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Several turbulence-related problems in engineering science have been studied. They include problems in wave propagation in turbulent media, turbulent transport, rough surfaces in hydrodynamic lubrication and scattering, structural stability under random loading, and stochastic inverse radiation.

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